analogous to the energy of position of a stone at the top of a cliff.

For instance, two bodies near one another may be endowed with a species of energy of position due to *opposite electrical states*, in which case they have a tendency to rush together, just as a stone at the top of a cliff has a tendency to rush to the earth. If the two bodies be allowed to rush together this energy of position will be converted into that of visible motion, just as when the stone is allowed to drop from the cliff its energy of position is converted into that of visible motion.

There is finally a species of molecular energy caused by *chemical separation*. When we carry a stone to the top of a cliff, we violently separate two bodies that attract one another, and these two bodies are the earth and the stone. In like manner when we decompose carbonic acid gas into its constituents we violently separate two bodies that attract one another, and these are carbon and oxygen. When, therefore, we have obtained in a separate state two bodies, the atoms of which are prepared to rush together and combine with one another, we have at the same time obtained a kind of energy of molecular position analogous on the small scale to the energy of a stone resting upon the top of a house, or on the edge of a cliff on the large or cosmical scale.

BALFOUR STEWART

FORMS OF ANIMAL LIFE

Forms of Animal Life; being Outlines of Zoological Classification, based upon Anatomical Investigation, and illustrated by Descriptions of Specimens and of Figures. By George Rolleston, D.M., F.R.S., Linacre Professor of Anatomy and Physiology in the University of Oxford. (Oxford: Macmillan and Co., 1870; Clarendon Press Series.)

I.

THIS long-promised and hoped-for book has at last appeared, and we may say at once that it fully maintains the well-earned reputation of its learned author. It will probably be most useful to his own pupils, for whom it seems to have been originally designed; and to those students of Comparative Anatomy who teach as well as learn.

The work consist of three parts: first, an enumeration of the anatomical characters of each sub-kingdom and class, arranged in a descending order from Mammalia to Gregarinæ—a plan less useful in most respects than the reverse one which is now generally followed. Next comes a minute description of certain dissected specimens in the new Museum at Oxford; and lastly an explanation of twelve plates, most of them original, which together supply a tolerably detailed account of the anatomy of at least one specimen of almost every class. "The distinctive character of the book consists in its attempting so to combine the concrete facts of Zoötomy with the outlines of systematic classification, as to enable the student to put them for himself into their natural relations of foundation and superstructure. The foundation may be made wider, and the superstructure may have its outlines not only filled up, but even considerably altered by subsequent and more extensive labours; but the mutual relations of the one as foundation and of the other as superstructure, which this book particularly aims at illustrating, must always remain the same." (Preface, p. vi.) This is very true, and it would have been well if all systems of classification had been thus based on anatomical facts. We may even suggest that the mutual relation of the foundation and the superstructure would have been still more obvious if the anatomical had preceded the systematic parts of the present work.

We propose, however, to follow Professor Rolleston's order, and to discuss here the classification he adopts, reserving an account of the second and third parts for a future article.

The question whether a perfect Zoological classification would be merely, like a perfect Nosology, a convenient method of stating and remembering a number of concomitant variations, or whether it would represent real genealogical relations between the several groups of animals, is one which has acquired great importance since the facts adduced by Darwin and Wallace have given probability to a modified form of the old theory of evolution. Most German naturalists fully accept this hypothesis, and employ their skill in constructing genealogical trees of each class. Dr. Rolleston holds that acceptance or rejection of the modern theory of evolution will depend on the particular constitution of each mind to which it is presented: "but," he adds, "whether the general theory be accepted as a whole or not, it must be allowed that in the face on the one hand of our knowledge of the greatness of the unlikeness which may be compatible with specific identity, and on the other of our ignorance of the entirety of the geological record, the value of the special 'phylogenies' reaching far out of modern periods are [qy. is] likely to remain in the very highest degree arbitrary and problematical."

It must, however, be remembered that, apart from its truth, a scientific theory may be very valuable by the accumulation of facts and the clearing of conceptions, to which it leads. Judged by this standard, the Darwinian theory is abundantly justified, not only by the observations of its illustrious author himself, but by the mass of excellent work it has evoked from others, especially in Germany. Indeed, from the results already gained, we may almost rank the theory of Natural Selection on a level with the teleological views which led Harvey to his great discovery, or with the belief in ideal archetypes by which Goethe was led to discover the presence of a præmaxillary bone in man, the "vertebral" construction of the skull, and the true morphology of a flower.*

Again, Dr. Rolleston enumerates the many similes by which men have endeavoured to represent the system of nature, and prefers the comparison of the groups of animals to the islands of an archipelago. Most readers will probably find the metaphor of a tree with its branches more useful, especially if existing forms are regarded according to Prof. Flower's ingenious suggestion, as the transverse section of such a tree, cut off at the present stage of the world's history. But, after all, by far the most natural, convenient, and almost inevitable metaphor is that of a great nation of common descent, not divided by one of the subjects into the arbitrary "provinces" of a kingdom, or "classes" of an army, but falling naturally into "alliances" which are those of blood, "families" which depend on common parentage, and "orders" which are hereditary. Now it is a great point gained to know that, probably, at least, such natural and convenient language is no metaphor at all, but strictly and literally true.

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* Die Descendenztheorie wird so eine neue Periode in der Geschichte der vergleichenden Anatomie beginnen. Sie wird sogar einen bedeutender en Wendepunct bezeichnen als irgend eine Theorie in dieser Wissenschaft vorher vermocht hat, denn sie greift tiefer als alle jene, und es gibt kaum Einen Theil der Morphologie, der nicht auf's Innigste von ihr berührt würde. (Gegenbaur; Grundzüge der Vergl. Anat. 1870, p. 19.)

Prof. Rolleston follows Gegenbaur in elevating *Echinodermata* to the rank of a primary division, and its various orders to classes; and also in including under the head *Vermes*, not only the *Rotifera* and *Helminthes*, which, as "Scolecida," form, with Echinodermata, Prof. Huxley's Annuloid group; but the *Annulata* as well, which have been associated with the Arthropod classes by all other naturalists since Cuvier (see the long and valuable note on pp. 152-157). On the other hand, *Tunicata* and *Polyzoa* are not also placed in the same heterogeneous crowd of "Würmer," but are retained in their probably more natural position among the Mollusks. Indeed, the classes included by Dr. Rolleston under Vertebrata, Arthropoda, Mollusca, Cœlenterata, and Protozoa, are almost precisely the same as those recognised by Prof. Huxley, and generally admitted in this country. The only variation is in re-admitting Radiolaria among Rhizopods, and making "Ctenophorae" (why not Ctenophora?) a separate class, instead of an order of Anthozoa.

The "characteristics of Vertebrata" are given with the fulness and accuracy which mark the author's work. The eight closely-printed pages devoted to this section may be advantageously compared with the very short, but masterly account of the same group in Prof. Huxley's "Introduction to the Classification of Animals." Indeed, we would advise all students to read thoroughly the latter work before beginning the one under review, which would then admirably fill up the details of the London professor's sketches. At p. xxxv., it is implied that the kidney of Amphibia and most fishes answers to the permanent one of other vertebrates; its homology with the Wolffian body is, however, rightly stated at p. lxiv. We would suggest that the terms "outer" and "inner," are better than "uppermost" and "lowermost," to denote the serous and mucous layers of the germinal membrane; and at p. xl. "ventral" should replace "anterior,"—a term which confuses by mixing up the relations of human anatomy with those of general zootomy. We are not surprised that Dr. Rolleston refuses to accept Hæmatocrya as a natural group of Vertebrata; he follows Prof. Huxley's division into Branchiata and Abranchiata, and of the latter into Mammalia and Sauropsida. Anammiota is a better alternative name for Branchiata than Anallantoidea; not only for euphony, but because an allantois is certainly present to some extent in certain Ichthyopsida, while its development and importance in mammals is far less than in birds and reptiles. In describing the characters of Mammalia, we notice that the author endorses Prof. Huxley's revised opinion that the malleus, not the incus, represents the quadrate bone, although the opposite is stated at p. 25 of the second part; but he appears to regard the marsupial bones as part of the pelvis, and not as mere ossifications of the internal pillar of the abdominal ring. The orders of the vertebrate classes are adopted from those given in the "Introduction to Classification" before referred to. That most of these will receive general assent there can be little doubt; but with respect to the placental classification of Mammalia, we venture to suggest some objections. In the first place the structure of the uterus and placenta is not strictly an embryonic character, but belongs to the parent organs of generation, which, in other classes, are found to be of minor importance in classification. Then it is very difficult to get accurate information as to the condition of the placenta—opportunities for observing parturition are, of course, much less frequent than for studying almost any other process—so that it will be long before we have any facts as to whole groups of animals, *e.g.*, the Sirenia. Moreover, if here opportunity is fleeting, judgment would seem to be often difficult: thus the placentation of so common a mammal as the rat was completely misunderstood by an eminent naturalist, until his account was corrected by Prof. Rolleston's own dissections. Compared with the skeleton, the teeth, or even the brain, the placenta is a far less available criterion, and far more liable to misinterpretation. But even if this were not the case, a grave objection to the placental classification remains in the fact that it necessarily excludes all fossil forms, the study of which has been so well used as a help in tracing the affinities of living animals, and by none more than Prof. Huxley himself. Lastly, judging this system by the test of concomitant variation, it is surely sufficiently condemned by compelling together animals so different as Primates and Rodentia, Orycteropus and Simia, while it separates Hyrax from Rodents and Perissodactyla, to unite it with Carnivora. The better plan we conceive is that followed by Prof. Flower in his recent lectures, to place the several orders in as natural juxtaposition as may be, and to put placental characters on the same level only as those afforded by the brain or the extremities.

In the careful description of the Mollusca which follows, Dr. Rolleston does not divide the Gasteropoda into two classes; nor does he admit the constancy of the primary flexures of the intestine, which Professor Huxley has made an important criterion of all the Molluscous series. (See pp. 58, 68, and 235.) In the *Ascidia* this question of the intestinal flexure depends upon the view taken of their great branchial sac. Dr. Rolleston does not admit Prof. Huxley's theory of its being morphologically a pharynx, but with Mr. Hancock regards it "as homologous not with a dilated pharynx, but with the branchial cavity, and the inhalent aperture to represent not the mouth, but the inhalent syphon of the Lamellibranchiata" (p. 69). If this view be accepted, it unites the Molluscoidea more closely to the Mollusca proper, and is an additional argument against their association with Vermes. The remarkable observations of Kowalewsky and Kupffer on the resemblances to vertebrate structures in the larva of Phalusia are duly noted (pp. ci. ciii.) Dr. Rolleston says of the Arthropoda that they "have frequently been classed together with more or fewer of the Vermes in one subkingdom, that of the 'Annulosa;' and whilst by such highly organised forms as the marine *Polychæta* an approximation appears to be made to certain of the less specialised of the Crustacea; or even of the Myriopoda, or the larvæ of insects, amongst the air-breathing Arthropoda; the microscopic Rotifera connect the Vermes, to which Sub-kingdom they are to be referred, very closely to the Crustacea"* (p. cvii.)

Although Gegenbaur's union of the Polyzoa and Tunicata with Vermes is not adopted, Huxley's group of Scolecida is divided into the three classes—Nematelminthes, Rotifera, and Platyelminthes. The Annulata again are divided into Annulata proper and Gephyrea. Dr. Rolleston ranks the remarkable genus *Sagitta* under the Nematelminthes (p. cxxxvii.), again following Gegenbaur, instead of placing it in a class by itself, the Chætognatha of Huxley.

We would here venture to question the advantage of the practice so generally followed by zoologists of making a separate order or even class—which generally entails at least one new name—for every aberrant genus. If *Sagitta* cannot be ranked with Annulata or Vermes, it might well stand under its generic head, or as the representation of an isolated family. In the same way we would deal with Sir John Lubbock's genus *Pauropus*, in relation to the two orders of Myriopoda, with *Hyrax* among mammals, *Archæopteryx* among birds, and *Amphioxus* among fishes. It is in vain to try to make all our classes or orders "of equal value." When natural families have been defined and grouped around a typical genus, the ordinal arrangement should, to a great extent, depend upon the number of species and other points of practical convenience. We learn nothing more of the single animal *Amphioxus lanceolatus* by a special order or sub-class, variously named by each classifier, being framed for its reception. So again we do not see the necessity of marking the distinction of *Marsupiata* and *Monotremata* from other mammals by the invention of fresh names—names which in this case have been singularly inappropriate, since several placental mammals are "didelphous," and the word "ornithodelphia" implies that birds have a uterus, and conceals the sauroid rather than ornithic affinities of Monotremata.

The description given by Professor Rolleston of the Cœlenterata is somewhat meagre, but that of Echinodermata is remarkably full, and when read in conjunction with the descriptions of *Asterias* and *Pentactes* (pp. 141-158, and 223-229, Plate x.), constitutes a valuable monograph of this complicated and interesting group of animals. Here, however, as in many other parts of the book, a few rough diagrams like those in the "Introduction to Classification," and in Prof. Greene's admirable monograph of Cœlenterata, would have been exceedingly useful, especially in explaining the more difficult points of embryology.

In treating of the Protozoa, with which the Infusoria are, we think, rightly associated, Professor Rolleston introduces a valuable disquisition upon the limits of the animal and vegetable kingdoms with the admission that "it is not rarely difficult to differentiate a unicellular organism as animal or vegetable, unless we happen to be acquainted with its past or future history" (p. clxii.). He does not admit Häckel's intermediate kingdom Protista, agreeing with almost all English naturalists in regarding *Monera* and *Protoplasta* as allied to Rhizopoda, and *Myxomycetæ* and *Flagellata* as vegetable organisms. He justly regards the chief difficulty to lie in the establishment of such statements as that animalcules as high as *Actinophrys* have at one period undoubtedly vegetable characters; but at the utmost the indeterminate groups would include very few of the organisms claimed by Prof. Häckel for his new kingdom.

In addition to the criteria usually given between animals and vegetables, it would seem that in all cases of true ovulation, the animal embryo absorbs its yelk from inside, while that of a seed is itself surrounded by the albumen; if this difference proves to be universal, it would be a remarkable foreshadowing of the mode of nourishment of adult animals and plants respectively.

OUR BOOK SHELF

The Handy Book of Bees, being a Practical Treatise on their Profitable Management. By A. Pettigrew. (William Blackwood and Sons, Edinburgh and London.)

THIS book will be invaluable to the beginner in bee-keeping, and will probably contain many useful hints to the more experienced. The author is one of a family of beekeepers, who have always made a large profit from their bees. He is eminently practical, and the greater part of the work consists of careful notes on the various details of successful bee management. In the descriptive parts he is also very good, but is not quite so successful when he comes to treat of some disputed points in the economy of bees. For example, he maintains the theory that the eggs of bees are of no sex, and can be made into queens, workers, or drones, as the wants of the community render necessary. In this he is opposed to all the great authorities who have studied bees; and he even gives a series of letters from Mr. Woodbury, of Exeter, on the question, which are almost conclusive as to eggs being of two sorts when laid, one producing drones only, and not capable by any subsequent treatment of producing anything else; the other capable of producing workers or queens, according to the treatment they receive. His arguments against this view are of the weakest, and he suggests an experiment, which, he says, "is within the reach of very inexperienced persons," and which would completely settle the question; and yet he writes a book in which he brings up the subject, and opposes the best authorities, without having first taken the trouble to make the experiment himself! Again, he states positively that worker-bees live nine months only—never more; yet he gives no account of how this can be ascertained, or refers to the variety of opinion that exists as to their longevity.

As an example of the valuable matter in the practical part of the work, we quote his recipe for fumigation. "A few puffs of smoke from a bit of corduroy or fustian rolled up like a candle, stupefies and terrifies bees so much that they run to escape from its power. Tobacco smoke is more powerful still, but it has a tendency to make bees dizzy, and reel like a drunken man; besides, it is far more expensive, and less handy. Old corduroy or fustian is better than new, unless the matter used to stiffen it be completely washed out. The stiffening matter won't burn. The old worn-out and castaway fustian and corduroy clothes of labouring men cannot be surpassed for the purpose of stupefying bees. Let me ask the most timid bee-keeper in the country to try it. Get a piece the size of a man's hand, rolled up rather tight, and fired at one end—not to blaze, but simply to smoke. Let him now place the smoking end so close to the door of a hive that all the smoke may go in when he blows on it. After six or eight puffs have been sent into the hive, let him lift it off the board, turn it gently over upside down, so that the bees and combs stare him in the face.

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* This sentence is a fair specimen of the author's compressed and parenthetical style, which sometimes reminds the reader of Lord Bacon and sometimes of S. Paul. A large insertion of brackets and dashes, of which there is scarcely one throughout the book, would often make plain the difficulties of a Thucydidean sentence, but even then only persons of great vital capacity could read the book aloud.